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THE MANCHESTER
STEAM USERS' ASSOCIATION.

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MEMORANDUM BY CHIEF ENGINEER,

PRESENTED AT THE

ANNUAL MEETING

OF THE

GENERAL BODY OF THE MEMBERS,

HELD ON

TUESDAY, MAY 29TH, 1900.

MANCHESTER:
TAYLOR, GARNETT, EVANS, AND CO., LTD., BLACKFRIARS STREET.
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ACCUMULATED FUNDS, £21,000.

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ROBERT TONGE.

MEMORANDUM BY CHIEF ENGINEER.

TUESDAY, *May 22nd, 1900.*

TO THE EXECUTIVE COMMITTEE.

GENTLEMEN,

I am again in the position to be able to report that during the past year very satisfactory progress has been made by this Association. Not only has our membership and the number of our boilers increased beyond last year's rate, but the number of boilers designed by us and inspected during construction is even larger than last year's very substantial figure; the number being 236. 564 old boilers were for the first time submitted to us for inspection, making a total of 800 first inspections; but 45 could not be accepted, as in our opinion they were too weak for the proposed working pressure. Amongst these were 22 second-hand boilers which we have every reason to believe were, on the strength of our reports, not accepted by the intending purchasers. There has been quite an extraordinary demand for second-hand boilers, due undoubtedly to the present industrial activity in this country. To the same cause must also be ascribed the large number of small damages to many boilers, they being now worked harder than before and for longer periods without sealing, until there is trouble with the furnaces. These are, of course, accidents over which this Association has no control, although in many cases claims have had to be paid under our guarantees. A summary of similar boiler mishaps, reported to us during the last ten years, will be found in the last two columns of Table IV., which was prepared for the Select Committee on Boiler Registration and Inspection now sitting, with the object of showing that, if our system of inspection had been in force throughout the country, the 502 land boiler explosions since 1882, causing 259 deaths and 656 injuries, and reported upon by the Board of Trade, would have been reduced to 202 explosions in 16 years, with 86 deaths and 215 injuries. The table also shows that, amongst our 137 damages during ten years, none have caused either death or injury. It is therefore reasonable to suppose that an efficient system of inspection leads to boilers being well cared for.

It is interesting to note that in ten years we have had 35 cases of fires being lighted by the night watchman when there was no water, or not enough water, in the boiler. This is more than 50 per cent. of the cases which may be classed as attendants' negligence. In none of the boilers with low-water safety valves has there been damage due to attendants' negligence. The overheating and injury of an empty boiler cannot, of course, be prevented by low-water safety valves; but as no pressure can accumulate in boilers so equipped, explosions are made impossible. I regret to have to say that the management of boilers is not always what it should be, and during these ten years we have had 45 cases of overheating due to sediment, scale, pulp, salt and dense

waters. The fireman has, of course, no choice as regards feed water, nor as regards time for scaling, which matters are entirely in the hands of the manager; but it is amongst these 45 cases that the only really threatening mishaps are to be found. There is no known device which will give warning as to when a boiler plate has become overheated, due to scale, &c., and the only means for preventing this is to keep the boilers clean.

SCALING BOILERS.

In my Memorandum, dated 1898, and in numerous circulars subsequently sent to firms who were troubled with sedimentary water, the suggestion was made that the usual method of removing scale from boilers was not a satisfactory one, that by opening the boiler for cooling it, the scale, coming in contact with the air, grows hard and adheres so firmly to the plates as to require chipping. It was therefore suggested that the method should be tried of slowly cooling boilers with water in them, and running this out foot by foot while the inside scraping and brushing progressed; for it had been found that the scale would then come off quite easily. The inconvenience of this method is that it takes several days to cool the boiler and the inside is, of course, quite wet while the men are in it. Some men like this method, while others have protested; but the experiment of providing them with oilskin suits seems to be much appreciated. Where the men are willing, and where time is available, this method is therefore to be recommended. Where the men are willing but time is wanting, the following method has been suggested. After drawing the fires, start the feed-pump, if possible through the economiser, and at the same time blow off the boiler, preferably by the scum, if fitted. The boiler will by this means be cooled rapidly and the air has no chance of coming in contact with the scale, which will then be found to come off easily. This method has been in use for many years in some works under our care, and is satisfactory.

If the men object to clean wet boilers, the following fairly rapid method should be tried.

After drawing the fires, wait till the firebridge is sufficiently cooled down, then blow down the boiler till it is empty. Some recommend a high pressure for this purpose, others a low pressure. When empty, allow the boiler to cool *without* opening any manhole doors or valves. When cool, the scale should shell off in large flakes. From boilers provided with low-water and high-pressure safety valves the air cannot, of course, be excluded, as these valves open when the water falls; but, as will be seen by the following summary of reports by our inspector at Halifax, even where these valves are fitted, the method works fairly satisfactorily. Reports from other works do not as yet give any marked indication as to whether any one of these systems is or is not best adapted for particular classes of boiler scale.

SUMMARY OF THE WORKING OF VARIOUS SYSTEMS OF SCALING BOILERS.

I. Three systems were tried at one factory. The boilers had no low-water safety valves and were fed by river water.

(*a*) One boiler was blown off with lowest possible steam pressure, and allowed to stand empty till cool. The scale came off easily in flakes.

(*b*) One boiler was partially blown off under pressure, refilled with cold feed, and this process repeated till the pressure was gone. It was then allowed to stand till cold, and emptied and cleaned. The scale was soft, but did not come off quite so well as in case (*a*).

(*c*) Two boilers were slowly cooled with water in them. This took several days. They were then cleaned with brushes and scrapers while the water was being lowered. This system gave the best results, the scale being quite soft.

The previous practice had been to blow off with the lowest possible pressure, and then to open all the manholes. The scale thereby became hard, and had to be chipped off.

II. At another factory, where low-water safety valves were fitted, which could, of course, not be closed when the boiler was empty, it was found that if the boiler was blown out under pressure and then allowed to cool, the scale was harder than if the boiler was cooled slowly with water in it, but the scale was partially lifted off the plates. Feed water was from river.

III. At another factory, with low-water safety valves on the boilers, the systems I. (*a*) and I. (*b*) were tried, and no difference was found in the labour, except that in the case of the boiler blown off hot the scale lifted itself off, while in the other case it was soft and had to be scraped and brushed off. Feed water was from river.

IV. At another factory it was stated that, to allow the boilers to cool with water in them was the best method; that if the work of removing the scale was done quickly there was no advantage in lowering the water foot by foot while the men were in the boiler.

V. These works arrived at the same conclusion as IV.

VI. At these works the men are provided with oilskin waterproofs. The boilers are cooled with water in them, and the men enter the boilers while the water is being lowered. This system has been in use for two years, and gives very good results. The men like it.

The opinion expressed by the Engineer of Works I. is that, where there is a spare boiler the best system of scaling is to allow the boiler to cool with water in it, and to remove the scale with water jets, brushes, and scrapers. Where there is no spare boiler, and where there is little available

time, the boiler should be blown out and cooled while empty, all air being excluded. Of course, his opinion is based on his own experience with boilers having no low-water safety valves, and which can, therefore, be hermetically closed. If air cannot be excluded and if time is an object, the boiler should be cooled by adding feed water; then the scale will remain fairly soft, and can be scraped off.

We have frequently been asked to express an opinion as to the advisability of treating the feed water before it enters the boiler; and in some large works we had no hesitation in recommending this course to be adopted, but such recommendations can only be made when all the details are known.

Where water is corrosive, this is generally due either to occluded air or to chloride of magnesia. In the latter case caustic soda is a remedy; in the former case sewage or other oxidisable matter seems to give relief, or zinc slabs have to be placed inside the boiler. Internal remedies can, however, only act locally, and, therefore, where the feed water is not treated before entering the boiler, it is very necessary that the anti-corrosive chemical should be well and uniformly mixed with the feed. This is most effectively done by passing it through a mixing tank. A very effective alternative is to add the chemical very slowly but continuously to the feed by means of a small oil pump. To illustrate the necessity for thorough mixing, it may be pointed out that if the chemical—say, caustic soda—were not added to the feed, but were pumped into the bottom of the boiler, where it would remain for a long time, whereas the feed would enter at the water level, the corrosive ingredients contained in the latter would do the full amount of harm to the boiler plates, and the corrosive power of the water would have been spent long before the caustic soda would mix with it. A thorough mixing before entering the boiler is, therefore, essential.

Many steam users still believe that there are harmless boiler compositions which dissolve scale. This is a mistaken notion. The more harmful composition may even contain sal-ammoniac or acids, especially if they are said to possess scale-loosening properties. With such compounds the acid would pass through the scale and corrode the iron. By this means a layer of soft rust is formed between the iron and the scale, and the latter can be shelled off. Such compounds should be condemned, or if they are used as a drastic measure, this should be done only for a limited period, just before cleaning the boiler, and the scaling should then be thorough and complete, because after a time the scale, rust, and iron will be cemented together more firmly than ever. The chances are, however, that the acids will attack the iron plates which are least covered by scale, and will not loosen the scale where it is thickest. The scale-loosening property of other compounds is based on the assumption, which is generally true for new scale, that it contains sulphate of lime. If, then, just before cleaning time, enough soda is introduced into the boiler to

convert the sulphate into carbonate, it is evident that the change must have a temporary loosening effect on the scale, and when the boiler is empty this scale can be scraped off easily; but neither in this case nor the previous one will the scale dissolve off, and if the boiler is put to work again without scaling, this old scale will now grow harder than ever, and, what is worse, the so-called scale solvent will, on second application, not soften it again.

Many boiler compositions are believed to be capable of preventing the formation of scale and sediment. This also is a mistaken notion. Water containing a certain percentage of lime, either sulphate or carbonate, will, when in the boiler, deposit a certain quantity of scale or sediment, and where it is desired to keep the boilers clean, this can only be done by a preliminary treatment of the feed before it enters the boiler. Feed water containing only carbonate of lime can be made almost absolutely pure by the addition of caustic lime, and then depositing or filtering. If the water contains sulphate of lime, the water cannot be made pure, for although the lime can be precipitated as above, its place is taken by sulphate of soda, which, though it forms no scale, will after a time, as it is added to the boiler water, make it so dense that overheating may and has taken place. Occasional blowing off would prevent this. Waters containing magnesia are very objectionable, they are generally very corrosive, and if treated with soda the dangerous floury deposit is often formed.

The objections urged against the various feed treatments are the cost of the necessary plant and the attendance, but even in medium size installations the balance of advantages is generally in their favour.

If feed water is properly softened it will contain no sedimentary matter, nor will it be corrosive, and both boilers and economisers will have a long life. The wasting away of steel and iron plates quite obviously shortens the life of a boiler, but scale has the same effect, for wherever it covers a heating surface there the plates get overheated, at least partially, which leads to grooving or leaky seams. This wear and tear shortens a boiler's life very materially. At present the compound interest on a capital of £100 is, say, £100 in 23½ years and £300 in 47 years, so that if a boiler is worked under conditions which lead one to expect its renewal in 23½ years, a capital equal to the boiler value, say £600 for a large one, would have to be set aside. If the feed is carefully purified so that the boiler may last for say 47 years, only £200 need be set aside for its renewal. The difference, say £400 per boiler, would more than pay for purifying plant. In districts where the water is sedimentary, spare boilers have usually to be provided, but if purifiers were used they could be dispensed with. The scaling of boilers costs from 6s. to 10s. for each occasion, except if this work has been neglected and the scale has grown very hard, when its removal is more costly. The soda, or the compositions which are freely introduced into many boilers, are more costly than the chemicals required

in purifiers. Possibly 50 % may be saved under this head. On the other hand, the purifiers require looking after, say about one half to one hour per day per boiler, and where the feed is taken from the hot well there may be a loss of heat if the water is treated cold. In extreme cases this loss will amount to about 4 % of the coal bill. Of course where feed heaters are in use this loss does not occur.

Before deciding whether any particular treatment is desirable it is essential to know the chemical composition of the feed water, and in order to assist our members in this matter a laboratory has now been added to our offices, and Mr. W. B. Baron, B.Sc., has been engaged as chemist. He will be employed in analysing the principal sources of feed supply, and more particularly those whose sedimentary or corrosive nature make an inquiry desirable. He will, however, also be in a position to analyse waters for our members, and in any economic trial or inquiries which they may wish us to make, he will be able to carry out the necessary analysis of fuel and waste gases.

Inquiries were sent out to boiler makers as to the number of land boilers manufactured during the year 1899, and although the returns were not very complete they enabled me to make the following estimate, which is fairly correct:—

Lancashire, Galloway, and Cornish Boilers	3,630
Marine Type and Dry Back Boilers	760
Loco. Portable Boilers	5,730
Vertical and Patent Vertical	5,200
Total.....	15,320

This number does not include Marine Boilers intended for steamers, nor locomotive boilers, nor water-tube boilers.

In anticipation of possible boiler legislation, various statistics have been prepared which it was hoped would prove of value. Amongst these may be mentioned Table I., which is similar to Table X. of last year, and shows the numbers of different types of M.S.U.A. boilers. Unfortunately the system which was adopted last year of including only such boilers as were actually enrolled on the 1st January, which is the date for which the annual report is made out, was not adhered to, and the table includes a few boilers which have left us, and a still larger number which, as is our custom, have been thoroughly examined in anticipation of enrolment, but for which the fees were not paid on the 1st of January. In addition to this table, information has been collected as to the number of damages to our boilers. A brief summary was submitted to the Select Committee on Boiler Registration and Inspection *(see Table IV.)*, but this has had to be slightly revised. The detailed and corrected summary is contained in Table II.

It will be seen that the night watchman who lights the fires, without being sure of the water level, is responsible for 35 cases. Their cost to this Association was £285. 14s. 5d. The general cases of shortness of water, *i.e.*, defective water gauge, inattention, &c., number 28. To these have to be added 13 accidents for which the attendant is hardly responsible, as, for instance, a safety valve blown off its seat and the water priming out of the boiler. The boiler attendant, it is thus found, is responsible for £246. 6s. 5d. damage.

TABLE I.—Details of Boilers Enrolled.

Boiler Types.	Total Number.	Oldest Boiler.	Average Date.	Boilers fitted with Low-water Safety Appliances.					
				Floats only.	Floats and Fusible Plugs.	Floats Total.	Fusible Plugs only.	Alarms.	None.
Lancashire and Galloway	3,742	1850	1884	1,867	1,109	2,976	651	12	103
Cornish	1,183	1845	1882	141	143	284	783	8	108
Vertical	1,032	1868	1890	8	7	15	382	18	617
Loco. Type	651	1864	1888	..	..	..	617	2	32
Marine Type	186	1865	1891	..	..	..	4	1	181
Externally fired..	163	1856	1882	24	4	28	4	7	124
Water-tube	44	1873	1897	8	..	8	..	11	25
Total	7,001	....	....	2,048	1,263	3,311	2,441	59	1,190

TABLE II.

Minor mishaps, chiefly bulges or sprung seams, to land boilers enrolled with the Manchester Steam Users' Association during the 10 years 1890 to 1899.

Nature of Damages.	Types of Boiler.								Totals.	
	Lancashire.	Cornish.	Galloway.	Vertical.	Loco. and Multi.	Water Tube Incl. Field.	Externally Fired.	Patent.		
Furnaces bare when lighting fires..	17	7	4	2	4	..	..	1		35
Shortness of Water: General	14	7	3	1	1	2	..	..	28	
Do. Blow-out deranged	2	4	..	..	..	..	..	..	6	
Do. Feed deranged	..	2	1	..	..	..	..	..	3	
Do. Fusible plug failed	..	2	..	..	..	..	..	..	2	
Do. Safety valve blew-off ..	..	1	..	1	..	..	..	..	2	
Totals.....	16	16	4	2	1	2	..	..		41
Incrustation, pulp, salt, and dense fluids	17	5	3	..	3	3	1	..	32	
Grease in Boiler.....	4	3	3	..	3	..	..	..	13	
Totals.....	21	8	6	..	6	3	1	..		45
Miscellaneous.....	5	1	..	2	4	3	1	..		16
Grand Totals.....	59	32	14	6	15	8	2	1		137

The attendant is clearly not responsible for incrustation and other feed troubles. These have to be put down to management, and include 45 cases, costing the Association £275. 10s. 6d. Amongst the 16 miscellaneous cases may be mentioned accidentally feeding a boiler with dilute sulphuric acid, several fractures while cold, and fracture of stop valves and other cast-iron parts, making a total of £178. 16s.

One reason for making this investigation was to ascertain the relative merits of the low-water safety valves or alarms and of fusible plugs. Neither contrivance can prevent overheating from scale, but their influence should be felt when boilers are allowed to run short of water while under the care of the regular attendant, who, of course, knows what to do when he hears any alarm. It was found that, although we have 3,370 boilers fitted with low-water safety valves or alarms, we have, during the ten years under consideration, had no single claim from them under this head. There were four cases in which the water did get low, but the damage was so slight that no claims were made. The night watchman, however, who did not understand what the blowing of this valve meant, was responsible for six claims costing £68. 7s. If now we turn to the 2,441 boilers which are fitted with fusible plugs, we find a total of 19 cases due to the night watchman's negligence; of these 13 resulted in claims costing £202. 14s. 5d. While under the care of the regular attendant there were 33 cases of shortness of water, resulting in 16 claims costing £272. 6s. 5d. It cannot, therefore, be said that fusible plugs compare favourably with low-water safety valves, and although there are several types of boilers to which the latter cannot be fitted, it is nevertheless evident that their employment wherever possible should be encouraged.

BOILER LEGISLATION.

When Parliament reassembled in the early part of this year several Boiler Bills were introduced, including Clause 14 of the proposed Factories Act Amendment Bill. The very divergent views revealed by these Bills led to the appointment of a Select Committee, but not before I had thought it necessary to discuss Clause 14 with the Home Office and to point out that the proposal to make the boiler inspector there and then decide on the safe working pressure could not be carried out, and also that as this clause made the boiler owner responsible for the selection of a competent inspector it would be unfair to him not to define the meaning of a "competent inspector." Many other points suggested themselves as regards boiler legislation, but the essential ones may be briefly stated as follows: Those clauses of Sir William Houldsworth's Bill dealing with boiler inspection are admirably framed and should if possible be passed into law. None of the Bills contain a workable definition of "competent inspector." The difficulty could, in my opinion, be overcome by enacting

that a boiler may, as is done by this Association, be examined by a competent person (boiler inspector) under the direction of a competent engineer (indoor technical staff) who would be responsible for the competence of the inspector. The competent engineer should have both a practical and technical training, and, besides knowing how a boiler is built and worked, should be fully conversant with the strength of boiler materials and the forces and stresses to which the boilers and their fittings are subjected. To my mind the most competent authorities for deciding, at least as regards those of their own members who may apply as to whether they are competent for this work or not, are the Councils of the Institutions of Civil Engineers and of the Mechanical Engineers, while outsiders should be allowed to get certificates of competency from say the Board of Trade.

According to the proposed Factories Act Amendment Bill, boiler certificates must be inserted in the Factory Inspector's book. But in addition to this it would be well if not only the boilers in use but all boilers on the works were noted, but those which are not being used would, of course, be without certificates.

As will be seen later on, steam pipes, keirs, stills, &c., when they do explode are most deadly in their effect, and in my opinion they should also be inspected, though not on the same lines as boilers proper. One inspection of a steam pipe range is practically sufficient to enable a competent engineer to say whether it is safe, for nearly the only dangers to which it is subjected are water hammer action and expansion and contraction or vibration. Keirs, stills, and drying cylinders are frequently of the oddest shapes, of dangerous material, and badly designed. They are not subjected to the action of flames or hot gases, but on the other hand they are generally placed in crowded rooms. These steam and hot fluid vessels should therefore also be examined at least once in their lifetime, but better still annually.

Another matter which will have to be settled is the definition of "steam boiler" and steam or hot water vessel, for as soon as inspection is made compulsory not only the type but the minimum size will have to be defined.

It appears to me that the competent engineer who makes the first inspection might be permitted to give a certificate that the vessel is either so small or so safely built or so placed that it can do no damage in its lifetime, but as regards boilers he should only have power to deal with them in this way if their internal capacities are below a certain volume, say three cubic feet.

TABLE III.

Number of land explosions, killed and injured, reported on by the Board of Trade in 16 years, 1882-1898, distinguishing types of boilers, &c., and causes of explosions.

Causes of Explosions and Exploded Objects.	Types of Boilers.																	
	Lancashire and Cornish.			Egg-ended and Various.			Water Tube.			Locomotive.			Vertical.			Totals.		
	No.	K.	In.	No.	K.	In.	No.	K.	In.	No.	K.	In.	No.	K.	In.	No.	K.	In.
Feed or gauge neglected ..	18	13	10	11	5	9	..	..	..	3	2	1	9	3	4	41	23	24
Gauge out of order	8	9	9	2	..	4	..	..	..	2	1	1	2	..	1	14	10	15
Fired empty boiler	1	..	1	..	..	..	..	..	..	..	..	..	3	1	..	4	1	1
Blow-off open or leakage ..	8	2	2	1	4	11	..	..	..	..	..	..	..	..	..	9	6	13
Total short of water cases ..	35	24	22	14	9	24	..	..	..	5	3	2	14	4	5	68	40	53
Safety valve inoperative ..	1	1	..	2	11	23	..	..	..	8	5	10	13	5	31	24	22	64
Attendants' faults	36	25	22	16	20	47	..	..	..	13	8	12	27	9	36	92	62	117
Sediment and impure feed—Management responsible ..	4	..	7	4	..	..	5	3	3	..	..	..	11	3	13	24	6	23
Defective design and material	24	16	44	14	18	42	..	2	7	7	2	3	16	7	26	61	45	122
Internal corrosion	24	15	20	12	11	19	..	..	..	46	14	56	93	38	101	175	78	196
External corrosion	38	29	59	16	17	37	1	..	..	..	..	..	..	..	..	55	46	96
Grooving and seam rips ..	..	..	..	9	4	27	..	..	..	..	..	..	..	..	..	9	4	27
Total—Inspectors' fault ..	86	60	123	51	50	125	1	2	7	53	16	59	109	45	127	300	173	441
Small tube failures	..	..	..	..	..	..	..	..	..	40	6	33	5	1	..	45	7	33
Manholes, fittings, &c.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	22	5	16
Miscellaneous	2	2	2	4	1	1	..	..	..	2	1	6	3	1	3	11	5	12
Faulty repairs, &c.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8	1	14
Total—Boilers proper	128	87	154	75	71	173	6		10	108	31	110	155	59	179	502	259	656
Steam pipes	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	28	18	34
Steam stop valves	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	22	10	19
Economisers	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	12	7	10
Chemical and other stills ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	21	20	19
Keirs and other hot fluid vessels	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	45	32	90
Drying cylinders, steam chests	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	34	10	28
Various, chiefly steam baking ovens	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	17	5	6
Boilers and coils, used for heating buildings, mostly due to frost	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	73	6	21
																252	108	227
Total explosions on land																754	367	883

TABLE IV.

Summary (of Table III.) of actual boiler explosions on land reported to the Board of Trade during 16 years, compared with behaviour of about 6,000 boilers enrolled with the Manchester Steam Users' Association during the past 10 years (Summary of Table II.):—

Nature of Explosion or Mishap.	Board of Trade Explosion Reports, 16 Years.		M.S.U.A. Boilers, 10 Years.	
	No.	Killed and Injured.	No.	Killed and Injured.
Furnaces bare when lighting fires	4	2	35	0
Shortness of Water:				
Gauge glass misread, feed failure, or attendant's neglect	41	47	31	..
Gauge glass out of order	14	25	..	..
Blow-off, &c., deranged	9	19	9	..
Total shortness of water	64	91	40	..
Safety valves jammed, intentionally or by accident	24	86	1	..
Total due to attendant's neglect	92	179	76	0
Incrustation, pulp, sediment, dense water	24	29	32	..
Grease	..	..	13	..
Total for which management is responsible	24	29	45	0
Defective design, bad material, &c.	61	167	..	..
Internal and external corrosion	239	447	..	..
Total which good inspection would have obviated	300	614	0	0
Miscellaneous—including Bad repairs	19	32	14	..
Small tube failures	45	40	1	..
Manholes, pipe joints, plugs, fittings	22	21	..	..
Total miscellaneous	86	93	15	0
Total boilers proper	502	915	136	0
Steam Hot Water Vessels, &c.:				
Steam pipes and stop valves	50	81	..	..
Economisers	12	17	1	..
Stills and other vessels with chemical fluids	21	39	..	..
Keirs and other vessels with hot water	45	122	..	..
Drying cylinders and other vessels with steam	34	38	..	..
Various—chiefly steam baking ovens	17	11	..	..
Heating boilers for baths and hot air	73	27	..	..
Total steam and hot water vessels	252	335	1	0
Total explosions on land	754	1250	137	0

COMPARISON BETWEEN BOARD OF TRADE AND MANCHESTER STEAM USERS' ASSOCIATION'S EXPERIENCES.

In order to make fairly reliable comparisons between boilers reported on by the Board of Trade and those of our members, explosions happening on steamers have been excluded from Table III., and, further, steam pipes, keirs, &c., have been separated from land boilers proper. The results are given in Tables III. and IV., which contain all land boiler explosions inquired into by the Board of Trade during 16 years.

It will be seen from these Tables that from 1882 to 1898 there have been 502 investigations on explosions of land boilers. Of these, 92 (shortness of water, defective safety valves, &c.) are mostly due to negligence or wilfulness on the part of the attendant. The next class, embracing all cases (24) of scale, grease, salt or dense water, although grouped by the Board of Trade with the previous one, is evidently the result of bad or at least lax management, for the boiler attendant cannot decide that he will lay off the boiler for scaling, nor has he the choice of feed waters. The next two classes, embracing all cases (300) of corrosion and also of defective design, could have been obviated by proper inspection. The miscellaneous cases (86) given in detail in Table III. are mostly not explosions proper. In columns 3 and 4 of Table IV. have been placed the cases with which the Manchester Steam Users' Association has had to deal. *(See also Table II.)* As the boilers of our members are guaranteed against almost any accident, notice is sent to us in nearly every instance where the least mishap has occurred. Therefore, the 76 cases in column 3 Table IV. are not explosions, but are simply notices of shortness of water, several leading to no injury whatever, others being leaky seams which had to be repaired, and still others being only bulged furnaces. In only one case, due to scale, did the furnace tear. This was inquired into by the Board of Trade (No. 1130). Two other cases were inquired into: (Report No. 650) the boiler after our inspection was moved and placed so that the safety valve was jammed; the other (Report No. 1042) was a burst Field tube.

Our immunity from such explosions as are due to neglect on the part of the attendants, is owing to our practice of having low-water safety valves fitted wherever possible. The only danger to which a boiler is then liable is scale, grease, &c., leading to over-heating of the plates. Generally this over-heating causes slow bulging, which is discovered before it becomes dangerous.

It is further interesting to note that during the past ten years we have had no cases of wilful jamming down of the safety valve, showing that the conversations which our inspectors have with the firemen impress them with the danger of trying this sometimes very effective expedient of increasing the power of a boiler.

The most important lesson to be learnt from Table IV. is that we have had no accidents which could be attributed to either defective design or to corrosion, either internal or external, showing that careful inspection and thorough technical supervision is very effective in this respect. In contrast with this immunity, we find that in the United Kingdom there have been 300 explosions in 16 years, which thorough inspection could have obviated. This means that inspection would have reduced the 502 land explosions by 60 %. It is even safe to say that most of the cases of defective gauge glasses (14) of safety valves jammed down (24) would not have occurred. Instead of 502 explosions with 259 deaths and 656 injuries, there would only have been 164 boiler explosions in 16 years with 54 deaths and 136 injuries. But judging by our own experience, that inspection tends to improve boiler management and attendance, it is probable that these figures, small as they are, might have been reduced still more.

EXPLOSIONS OF STEAM PIPES, KEIRS, STILLS, &c.

An examination of Table III. shows that for every two boiler explosions one man has been killed and two and a half injured. The least injurious explosions are those due to small tubes in locomotive and other boilers, only one being killed for every sixth boiler explosion ; while the most fatal explosions are those in which the safety valve has been jammed down, either by accident or intentionally. Here almost every explosion results in one death and three injured. Again, comparing the various boiler types, we find that loco. boilers (generally agricultural) and vertical boilers (often on cranes) which stand in the open, are the least fatal, though the explosions per number of boilers in use is great. The next safest boiler in case of an accident is the Lancashire and Cornish, there being 87 deaths with 128 explosions. The egg-ended boilers are the most dangerous, there being more than one death and two and a half injuries for every single explosion.

If now we examine explosions of other vessels than boilers *(see Table III.)*, we find that boilers used for heating purposes are safest, there being only one death for twelve explosions. The most fatal explosions are those of chemical and other stills, doubtless due to the inflammable or poisonous nature of their contents. Steam pipes and stop valves are also fairly deadly, there being 28 deaths for 50 explosions.

Most of these latter accidents are due to water-hammer action, whose nature, I am sorry to say, does not appear to be properly grasped even by engineers, otherwise some pipe arrangements in use would never have been decided upon. But in every such case all danger, even now, can be removed by fixing automatic water drains.

Keirs and drying cylinders explode generally because they are badly designed for the pressure, or because of the use of cast iron. The cylinders

frequently contain only steam, and would be fairly harmless were it not that they form parts of machines on which workmen are necessarily engaged.

Economisers generally only explode when worn out.

Stills, as they contain volatile fluids which are capable of exerting enormous pressures even at low temperatures, require careful looking into in each case, but a competent engineer should even here be able to judge whether the design is a safe one. Their inspection, however, is attended with some difficulty on account of trade secrets.

In anticipation of the Select Committee's inquiries, information as regards foreign boiler legislation was also collected.

HISTORY OF BOILER LEGISLATION.

France.—Of France it can be said that boiler legislation commenced almost before the advent in their country of the steam boiler. In 1810 the danger of smoke being emitted by steam fire engine boilers led to the passing of an Act which prescribed that authorisation for steam boilers had to be obtained. Thirteen years later the necessity for having safety valves on boilers had made itself felt, and a law was passed that each boiler must have a lock-up safety valve. This law has been rescinded, but the principle lives on in our Board of Trade rules for marine boilers. About this time the first instructions to boiler attendants were issued. Three years later—in 1828—a law was passed prescribing a very severe hydraulic test for all new boilers. At the same time, and again in 1830, rules for boiler dimensions were issued. In 1832 further rules were added, prescribing the diameters of safety valves and insisting on fusible plugs. In 1839 a retrograde movement set in, and the hydraulic test pressure was reduced in severity, and then, in 1843, a very detailed boiler law came into force. It was an improvement on the previous severe laws, but it bristles with new minute regulations, which seem to have grown in oppressiveness until, in 1865, they were swept away by a new law. About ten circulars were issued in the interval, the first one extending the scope of the Act so as to include steam receivers. In 1847 three low-water indicators had to be fitted to each boiler. It was also stipulated that boilers must be laid down in certain directions, for it seemed to have been noticed that in cases of accident destruction of property was greatest at either end of a boiler.

In 1849 Bourdon's pressure gauges, a new invention, were allowed to replace the mercurial ones, and in 1861 rules for the thickness of *steel* plates were issued.

As already mentioned, in 1865 a law was passed which swept away many of the rules and regulations which Government officials had been slowly building up. Boiler makers were now free to build boilers of any dimension and any thickness and place them in any direction; safety

valves might be any size, steam receivers were not boilers, and the test pressures which had started at three to five times the working pressure were now reduced to those adopted by the Manchester Steam Users' Association. Inquiries into boiler explosions were ordered, and, strange to say, the law of 1810 was revived by certain clauses against the smoke nuisance. Furnaces might smoke, but steam boilers must not do so. In 1880 this regulation was dropped. In some of the previous laws, but more particularly in that of 1865, a system of boiler classification was adopted, which seems to have been based on certain speculations: that the larger a boiler, and the higher its working pressure, the more dangerous it must be. By multiplying the volume of the water contained in a boiler by the permissible working pressure, a figure was obtained which fixed the class. The most destructive class, *i.e.*, above a certain numeral, was not allowed in dwelling-houses.

This regulation had to be modified in 1880, for even then it had been found that high pressure boilers were not so destructive as low pressure ones. This law, however, revived the old restrictions about the placing of boilers, but in a modified form. Boilers of the most destructive class were not to be placed nearer to a dwelling than 10 ft., and unless they were distant at least 33 ft. a thick wall of 39 in. or more had to be interposed. This law is apparently still in force, and is inconvenient in so far as that the owner of a boiler is forced to shift its position, or at least to build the protecting wall, if his neighbour erects a dwelling within a distance of 33 ft. from the boiler. It is interesting to note that water-tube boilers, because of their small water volume, belong to one of the less dangerous (French) classes, and being subjected to fewer restrictions in that country, naturally grew in favour. This is especially true of the Belleville type which has now been introduced in our Navy.

The 1880 law also insists on a hydraulic test every ten years instead of the previous regulation of a test when new, when repairs were effected, and when a boiler was sold.

Steam receivers of three cubic feet capacity were again classed as boilers, and so were hot water tanks of the same capacity if under pressure.

The most important clause of this Act is the one which says that steam users must not only see that their boilers are in a safe condition, but must have them inspected at intervals which are sufficiently close together. Another clause provides that if an inspector of mines has reason to believe that a boiler is unsafe, he may have it tested, but if the boiler is under the inspection of an association, their certificate will be accepted as proof that the boiler is safe. By this means nearly all French boilers have been driven into the arms of the various Boiler Associations.

Prussia.—In 1872 most boiler laws, including one which is dated 7th May, 1856, were cancelled. There then remained only two laws in

force—the first dated 21st June, 1869, and the second dated 3rd May, 1870.

The first of these laws regulates the laying down of new boilers, while the second regulates the inspection of boilers which are in use. Until then all boilers were under Government inspection, but now voluntary inspection was recognised. This point was further dealt with in a law of the 15th March, 1897. Numerous other boiler laws and police regulations have come into force since 1872, and the present position is practically as follows:

No boiler may be used which has not been inspected when new and which is not being inspected subsequently.

Such boilers as are under State inspection have to be examined externally when they are 2, 6, 10, 14, &c., years old. They have to be examined internally and externally when new when 4, 8, 12, 16, &c., years old, and have to be tested by hydraulic pressure when new and when 8, 16, &c., years old.

Boilers which are under the care of Boiler Associations have to be examined according to the regulations laid down by the Government in the respective charters. These regulations are framed on the basis that there shall be one bi-annual "entire" examination and one or two external ones. The conditions under which these charters are obtained are that only such engineers are employed on particular duties as have obtained Government certificates of competeney, of which there appear to be eight classes:—

1. Competence to examine and test old boilers.
2. Competence to test boilers after repairs.
3. Competence to test new boilers for members.
4. Competence to test new boilers built by members.
5. Competence to pass new portable boilers.
6. Competence to pass new fixed boilers.
7. Competence to examine requests for inspection.
8. Competence to test vessels not included under the name steam boilers.

Other German States have to a large extent followed Prussia's example.

Austria.—Austria commenced legislating on boilers in 1813, or rather on steamers, but as none ventured to navigate her waters for the following four years, a new law was passed which amongst other matters fixed the test pressure at eight times the working pressure, while inspection was to be compulsory and annual. Over-pressure was to be guarded against by fusible plugs. Many Land Boiler Acts were passed, commencing 8th September, 1829. The law dated 7th July, 1871, remained in force until 15th July, 1891; but in the meantime innumerable regulations and decisions have

been published by the Home Secretary on the recommendation of a standing Consultative Committee on Boilers, which is one of the distinctive features in Austrian boiler legislation.

The law of 1871 permitted boilers to be inspected and even insured by Boiler Inspecting Companies, of which two now exist—one for Austria and one for Bohemia—and they are, of course, all-powerful. In cases of doubt these companies or their members appeal to the Home Secretary, who submits the case to the Consultative Committee, who, when they feel themselves incompetent, submit the case to the Technical College at Vienna. Their opinion is transmitted back to the Home Secretary, who issues it to the applicants. The large number of these appeals now constitutes a very formidable network of regulations, which cannot easily be broken through.

Boiler attendants must by law be certified, but according to one of the Committee's decisions, firemen are not necessarily boiler attendants.

BOILER INSURANCE.

Boiler insurance in Germany, France, and other countries where inspection is compulsory, is effected with fire insurance companies and industrial insurance companies, and, as far as my information goes, the official sanction given to the German and French Inspection Associations would be at once withdrawn if they commenced insurance operations. The only exception is the Association Alsacienne, who are allowed to give guarantees of safety; but these only cover such mishaps as are due to negligent inspection or reporting. The ordinary accidents are excluded from their guarantees.

A condition very similar to that of continental boiler inspection and insurance exists as regards shipping. Vessels, engines, and boilers which are classed by Lloyd's Register, and others, or certified by the Board of Trade, but never insured by them, are quite easily insured with Lloyd's underwriters and others. The inspector is absolutely unbiassed either one way or another; he has no pecuniary interest in the vessel, its engines or boilers, his report is perfectly impartial, and the greatest possible confidence is placed in it by the underwriters.

Years ago it would have been impossible to copy this system for land boilers for England, because millowners were not liable as they are now for the consequences of accidents, and as they have been for many years on the Continent. The average cost of a boiler explosion in England is hardly likely to exceed 1s. per boiler, but it is evidently absurd to expect underwriters to take only a small multiple of this little sum as a premium to cover a boiler explosion which might cost £1,000. Now, however, since the employers' liability is increased, and large premiums are paid for factory insurance, there is no difficulty in arranging that the risk for

certified boilers shall be covered by the same policy; an extra premium of one shilling per boiler would be ample.

PERIODS OF INSPECTION.

France.—Boilers must be inspected by Government when new, when repaired, and when changing hands, also every tenth year, and they have then to be tested by hydraulic pressure. Voluntary inspection must be at reasonable intervals. This is interpreted to mean one entire examination every twelve months and other external examinations.

Prussia.—Boilers must be inspected either by Government or by a recognised association. Entire Government inspection when new, and then every fourth year, with a hydraulic test every eighth year. Also an external examination when two years old, and then every fourth year.

These inspections are not necessary if the boilers are enrolled in a recognised Association. In that case the usual periods of inspection are bi-annual, but the Government stipulates the details before the concession is granted to the inspecting associations.

Lloyd's Register inspect marine boilers when new, when four years old, when six years old, and then annually. A fairly long life for these boilers may be taken as 20 years, whereas land boilers may last twice as long. These boilers are, however, inspected frequently, say every three months, by the chief engineer of the vessel, and also by the superintendent engineer.

Board of Trade inspect marine boilers annually.

The M.S.U.A. practice is to inspect boilers annually, both internally, externally, and under steam.

BOILER INSPECTION SYSTEMS.

(*a*) The M.S.U.A. and probably all English Boiler Insurance Companies employ—

1. Boiler Inspectors and
2. Technical Staff.

The Boiler Inspectors are men specially trained to their work, and report full details of the boilers they inspect. These reports are carefully examined by the indoor engineering staff, who fix the safe working pressure. The M.S.U.A. central office then issues a detailed report to the owners, also certificates to suit certain authorities.

Lloyd's Register Engineer Surveyors are competent to fix the working pressure of the boilers they inspect. They report to head-quarters, where their reports are controlled, and if satisfactory the boiler is accepted for classification. The result is published at once. The owner receives no report as to the condition of the boiler.

On the Continent inspectors are considered competent to fix the safe working pressures of boilers. Their certificates of safety are therefore accepted without being reported upon by an indoor staff, although they are checked there.

INFLUENCE OF DIFFERENT SYSTEMS OF INSPECTION.

There must always be a fundamental difference between State inspectors and private inspectors. The doings of the former can be reviewed by the State, and may lead to dismissal and loss of pension, but there is never any fear of loss of business. As a result the involuntary tendency of the majority of State officials is to safeguard themselves. For the protection of inspectors rules are framed and precedents collected, until the whole system grows to be exceedingly rigid, so much so that in France and Germany the Legislature had to break it down. Private individuals and firms aim generally at an extension of business; a retrograde motion is dreaded more than anything else, and therefore such boiler inspectors are on the one hand drawn towards making boilers safe, while competition drives them to make concessions. The higher the technical skill and training of such an inspector the farther can he advance, as regards improvements, without in any way running risks. Competition may, however, be purely commercial and not technical, and if the inspector is not competent to see danger, such competition is no gain to anyone. Where there is a monopoly and no competition the system is practically the same as that existing in a Government Department, unless—and this is a very important point—a substitute for competition is created. This is most readily done by means of a committee, on which the conflicting interests are represented. The wonderful success of Lloyd's Register is undoubtedly due to this cause. The conflicting tendencies as regards classification of ships are on the one hand those of underwriters who would condemn all unseaworthy ships, and might even like to condemn all except the stoutest ones; on the other hand, the shipowner wishes his ships to be as light as possible, so as to carry the maximum amount of cargo. These two interests are those principally represented on Lloyd's Register Committee, but, as is well known, the different ports send representatives, as do the different technical societies which deal with naval architecture and engineering. The result is a Committee which has sanctioned a set of rules which have every appearance of being framed so as to give every advantage to the shipowner, at the same time making the underwriters absolutely safe as regards structural strength of the ship which underwriters insure. Seeing that the annual premiums on vessels of the highest class vary within such wide limits as 3 and 30 per cent., it is evident that classed vessels are never thought to be lost because of weakness. The accidental risks—weather, navigation, &c.—are the only ones they run. The inspectors cannot protect them from these.

This same principle of artificial internal competition by means of a representative Committee is adopted in all other ship classification societies, and in all continental boiler inspection societies, and in the Manchester Steam Users' Association, where efficiency of inspection, cheapness of inspection, and safety without hampering progress are the competing interests. Committees on which these interests may be represented cannot, of course, exist in commercially-constituted Insurance Companies. There the place of controlling Committees is taken by the Boards of Directors, whose main object must be the payment of the highest dividends.

While going to press the appended Report of the Select Committee on Boilers Registration and Inspection has been published. In it prominence is given to the fact that accidents due to negligence on the part of the attendant are numerous, and that inspection could not prevent such explosions. *(Compare Tables III. and IV. and remarks on page* 15.*)* The Committee also point out that inspection by competent persons would tend to diminish the risk of explosion, but that the responsibility of the boiler user should be maintained. The Committee, therefore, favour extending the powers of the courts appointed by the Board of Trade to inquire into explosions, because their reports would bring home to the owners and users their responsibility. They also suggest that boilers which do not come under the notice of factory inspectors should come under the authority of the police.

I am, Gentlemen,

Yours faithfully,

C. E. STROMEYER,

Chief Engineer.

Manchester Steam Users' Association,
9, Mount Street,
Manchester.

APPENDIX.

Report of the Select Committee of the House of Commons on Boilers Registration and Inspection.

The Select Committee appointed to inquire into and report on the advisability of legislation to insure the systematic and regular inspection of boilers, with the object of diminishing the risk to life and property arising from boiler explosions, have agreed to the following Report :—

Your Committee met on the 4th May and have taken evidence on those subjects.

Your Committee have examined 22 witnesses.

They may be divided into the following classes :—

Three from the Board of Trade.

Six representatives of Boiler Insurance Companies.

One representative of the Mining Association of Great Britain.

Twelve representatives of various industries, including engineering, boiler-making, cotton spinning, agriculture, and chemicals.

Your Committee have also had before them the Report of the Select Committee on the same subject which sat in 1870-71; also the Board of Trade Reports on the Boiler Explosions Acts, 1882 and 1890.

In this Report your Committee have confined their attention mainly to boilers used for generating steam, fired either internally or externally.

Your Committee report that the evidence given before them goes to show that some explosions occur in boilers from mistakes or incapacity on the part of the attendant, undue pressure, loss of water, and other causes, and that inspection, however efficient, could not prevent such explosions.

Your Committee report that explosions undoubtedly occur more frequently in boilers which are uninspected than in those which are inspected by a competent person, and that every one of the witnesses, with the exception of two who expressed no opinion on the point, advocated the desirability of a systematic and periodical inspection of boilers used for generating steam, and recommended legislation making such inspection compulsory.

Your Committee consider that inspection by a competent person would tend to diminish the risk of explosion, but at the same time they hold that it is of the greatest importance to maintain the responsibility of the boiler user for the condition and safety of the boiler which he works.

Your Committee point out that there are three ways of bringing about more frequent inspection by competent persons :—

(1) By the appointment of inspectors under a Government Department.

Your Committee do not recommend this, as they consider :—

(*a*) That the responsibility of selecting a competent person should fall upon the owner or user of the boiler ;

(*b*) That the owner would shelter himself behind the inspector of a Government Department.

(*c*) That the inspectors under a Government Department would work upon inelastic lines, and that this would hamper the development of boiler improvement.

(2) By extending the powers of the court set up under the Boiler Explosions Acts, 1882-1890, giving that court power to inflict heavy penalties on the owner or user of a boiler in the event of an explosion, if it be shown (*a*) to the satisfaction of the court that such owner or user failed to have his boiler inspected by a competent person at a reasonable period prior to the explosion ; conditions of working, quality of feed water, and custom of the locality to be considered by the court when determining what a reasonable period is ; (*b*) that the boiler has been worked since the last inspection at a pressure exceeding that for which the boiler has been certified, or that there has been wilful and culpable negligence in carrying out any recommendations made at the last inspection ; also giving the court power to inflict like penalties on the inspector, if it be shown to the satisfaction of the court that the inspection was carelessly or insufficiently carried out.

Your Committee think that this extension of powers would tend to increased boiler inspection because the larger responsibilities of the owner or user would be brought home to him by public reports and by the various boiler inspectors or boiler inspection and insurance companies. Your Committee think that in these cases an appeal should be allowed, but they find great difficulty in suggesting the court to which such an appeal should be made.

(3) Your Committee further consider that an extension of the Factory Acts, empowering an inspector to call upon the owner or user of a boiler to produce a certificate or entry showing that he has had his boiler inspected by a competent person within a year, and providing that in cases where the Factory Acts do not apply this authority should be vested in the police, would make the inspection of boilers practically universal.

Your Committee do not consider that boilers working in or about mines should be subject to further legislation, as these boilers fall under the Mines Acts, and are already under inspection.

Your Committee consider that no legislation is necessary in the case of locomotives on railways.

Your Committee understand that hotels now come under the category of private houses, and that consequently if any explosion occur with a hotel boiler no inquiry is held under the Boiler Explosions Acts, 1882-1890, and they recommend that these Acts should be so amended as to include hotels and flats.

Your Committee have taken no special evidence in connection with boilers in ships, nor do they make any recommendation under this head, nor in respect to keirs, stills, &c., steam pipes, &c. At the same time the evidence shows that keirs and stills are liable to explosion, and when they explode may cause both damage to property and loss of life.

Boilers, as defined in this Report, are the only things upon which they report.

Your Committee consider that the boiler-making industry has made great strides in recent years; that boilers are, as a whole, better designed, better made, and better managed and understood than they were only a few years ago; and that legislation giving any Government Department control over the inspection of boilers would be a grave mistake.

Your Committee consider that State certification or registration, unless accompanied by State control, would not be of any practical value.

20*th July*, 1900.

4,500.
10-9-1900.

MANCHESTER STEAM USERS' ASSOCIATION.

PAST PRESIDENTS.

	YEARS.
Mr. HENRY HOULDSWORTH	1855—58
Sir WILLIAM FAIRBAIRN, Bart., C.E., F.R.S.	1858—74
Mr. HUGH MASON, M.P....	1875—86
Mr. RICHARD PEACOCK, C.E., M.P.	1886—89
Mr. HENRY LEE, M.P.	1889—93

PAST VICE-PRESIDENTS.

Mr. EDMUND ASHWORTH.
Sir THOMAS BAZLEY, Bart., M.P.
Mr. CHARLES F. BEYER.
Mr. JOHN PENN, C.E., F.R.S.
Mr. JOHN RAMSBOTTOM, C.E.
Sir JOSEPH WHITWORTH, Bart., F.R.S.

DISTINCTIVE FEATURES OF THE MANCHESTER STEAM USERS' ASSOCIATION.

This Association was founded in the year 1854, by Sir William Fairbairn, C.E.; Sir Thomas Bazley, M.P.; Sir Joseph Whitworth, Bart., C.E.; Henry Houldsworth, Esq., and other philanthropic gentlemen, for the purpose of preventing steam boiler explosions by competent scientific inspection of the boilers, and thus of saving human life.

This Association was the first institution to establish periodical boiler inspection on a practical basis.

The Association is not a Joint Stock Company. There are no shareholders to whom dividends are paid out of the members' subscriptions, but the income is appropriated solely to promote the direct objects of the Association. The Committee of Management is elected annually at a general meeting of the body of subscribers.

After a boiler has been examined and found fit for its working pressure, the Association gives a pecuniary guarantee of its safety to the extent of £1,000 or £2,000. In the event of explosion the guarantee covers both loss of life and property, as well as claims under the Employers' Liability Act and the Workmen's Compensation Act. The Association does not guarantee boilers on the principle of averages, but as the result of competent scientific inspection. Its object is Prevention, not Compensation; and its fundamental principle is—*No Inspection, No Guarantee.*